September 25, 2019

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

Re: Expanding Flexible Use of the 3.7 to 4.2 GHz Band, et al – GN Docket No. 18-122; RM-11778; RM-11791

Dear Secretary Dortch:

In accordance with Section 1.1206 of the Commission's rules, we hereby provide you with notice of an ex parte presentation in connection with the above-captioned proceedings. On September 23, 2019, Joseph Hanley (Sr. VP – Telephone & Data Systems, Inc.), Johanne Lemay and Robert Yates (Co-Presidents of LYA) along with the undersigned met with various FCC officials in separate meetings enumerated below.

In addition to discussing the attached presentation, U.S. Cellular also stressed the following positions:

- Mid-band spectrum is critical to successful 5G deployments, and even more so in the relatively lower density markets that U.S. Cellular serves.
- Mid-band spectrum is scarce in the United States, making it even more critical that all mobile network operators have fair access to it.
- The C-Band provides the best opportunity for mid-band deployments since it could be available in most markets, once cleared would be relatively clean and unencumbered, and is aligned with deployments globally.
- It is critical that at least 300 MHz of C-Band spectrum be made available.
- The best way to ensure a fair and transparent process is for the FCC to conduct the auction using the well-understood and highly effective non-combinatorial clock auction format it utilized in Auction 1000 and Auction 102 and plans to use in Auction 103.

- The FCC has a well established history of conducting successful auctions. FCC auctions contain key safeguards including:

  - Clearly defined service rules and buildout requirements.
  - Public notice and comment on proposed auction procedures.
  - Reserve prices and upfront payments, and absolute assurance that the auction will proceed to its logical conclusion and license transfer agreements will be entered into provided a reasonable aggregate reserve is met.
  - Enforcement of prohibited communications rules.
  - Bidder default rules.
  - Public disclosure and oversight of seller's affiliates and ownership structure in pre-auction filings.

Sincerely,

/S/

Grant B Spellmeyer
Vice President – Federal Affairs & Public Policy

List of Meetings

Office of FCC Commissoner Carr
Will Adams

Office of FCC Commissioner Starks
William Davenport

Office of FCC Commissioner Rosenworcel
Umair Javed

Office of FCC Chairman Pai
Aaron Goldberger

Joint Meeting with Bureaus

WTB
Donald Stockdale
Matthew Pearl
Anna Gentry
Brian Wondrack
Jeffrey Tignor
Paul Powell
Peter Daronco
Max Staloff

OEA
Giulia McHenry
Margaret Wiener
Martha Stancill
Patrick DeGraba
Evan Kwerel
Paul Lafontaine
Jonathan Campbell

Comments on the C-Band Alliance Proposed FUEL Auction

FCC Docket 18-122

September 23, 2019

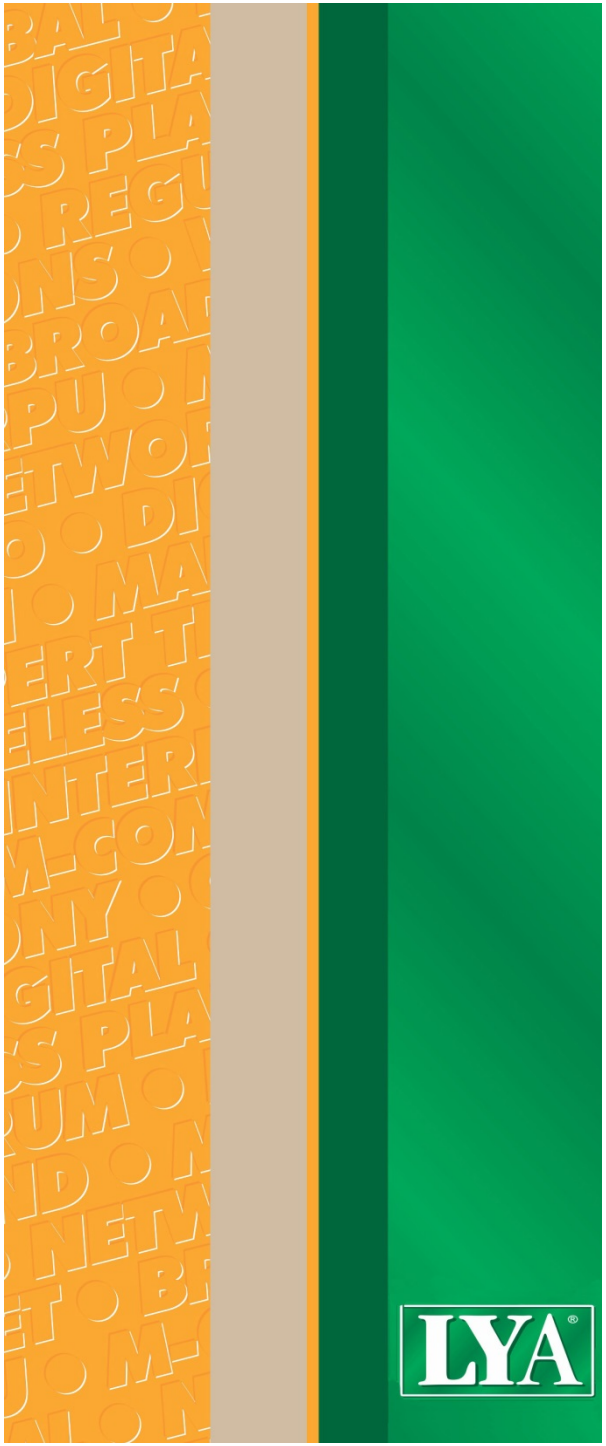


Table of Contents

Executive Summary

Executive Summary (1)

- US Cellular engaged LYA to review the C Band Alliance (CBA) FUEL Auction proposal:
  - CBA filed *ex parte* filing of June 12, 2019 including White Paper by Auctionomics, "FUEL for 5G: Flexible Use and Efficient Licensing" in which it proposes a Combinatorial Sealed Bid format for the private auction.
  - This Report provides LYA's comments on the FUEL auction format as proposed. LYA's comments are based on experience supporting bidders in spectrum auctions in the US, Canada and Europe, including combinatorial clock auctions, combinatorial sealed bid auctions, SMRA and clock auctions.
- The FUEL Combinatorial Sealed Bid auction would have no price discovery rounds. This is not a commonly used format for spectrum auctions:
  - Price discovery is an important element of any auction in order to find the correct prices: "As the bidding continues, bidders get a better understanding of what they may win and where their best opportunities lie…" Source: The Clock-Proxy Auction: A Practical Combinatorial Auction Design, Lawrence Ausubel, Peter Cramton and Paul Milgrom, Chapter 5 of Combinatorial Auctions, MIT Press, 2006, page 128. **[LYA page 12]**
  - An auction without price discovery comes with significant risks, which are disproportionate for small/regional bidders. Setting reserve prices at international benchmarks further biases outcomes. **[LYA page 26]**
  - LYA's experience with Combinatorial Sealed Bid Auctions confirms this – i.e. where there are no price discovery rounds – and highlights the risk of mobile carriers not obtaining spectrum where they need it.
  - Bidders need to be able to adjust targets as rounds progress instead of just taking risky "shots in the dark". A multi-round auction also increases likelihood of all licenses being sold; a better market outcome.
- There is, in fact, a trend away from using combinatorial auctions, notably in the UK (where the Combinatorial Clock Auction was first used) as well as in Canada and other countries. Other formats, such as the non-combinatorial Clock Auction, are more transparent, simpler for bidders and have fewer governance issues.
  - Combinatorial auctions have never been used in the US due to the large number of licenses for sale and the perceived associated computational risk.

Executive Summary (2)

- The FUEL auction would not be a suitable format for an important 5G auction:
  - The FUEL auction would be a complex and opaque process for all bidders.
  - There is no evidence that FUEL would be any quicker to implement than the well-known Clock Auction process. In any case the time required to run the C Band auction with another format is not a key factor, particularly for a strategically important 5G band. **[LYA page 10]**
  - Bidding with "bid groups" (increment-defined Exclusive-Or bids) increases risks with no benefit: bidders cannot adequately specify valuation function – assumes valuations are all additive, **[LYA page 17]**
  - The bid group collections are "implied bids" – this bidding language is prone to error – it is better for bidders to express demand for specific licenses; bidders do not have 10^{406} objectives in any case. **[LYA page 51]**
- The FUEL auction would be highly biased against small and regional bidders:
  - Insurmountable threshold problem: small bidders will only win in the FUEL auction if their bids either fit in with the bids of the large bidders or can somehow be combined to outweigh larger bids, **[LYA page 14]**
  - Large "national" bids would have an all-or-nothing feature across multiple EA's, a feature never used in past FCC auctions, further biasing the auction process against small and regional bidders,
  - There is a high risk for non-national bids – which can be placed by large and small bidders – due to winner determination by EA, which worsens exposure risk and specification problems. A bidder bidding in 10 different EA's is essentially being treated like 10 different bidders. **[LYA pages 15, 16]**
  - Large bidder use of the increment/decrement features to fit together, may mean that smaller bidders cannot win anything. The format promotes gaming and strategic bidding. **[LYA pages 24, 58-61]**
  - Strong Competitive measures are needed in combinatorial auctions as part of the format because of the threshold problem – e.g. caps and/or reserve blocks, etc. – and due to gaming incentives. **[LYA page 18]**
- A better and simpler mechanism would be a Clock Auction with blocks in categories. **[LYA page 40]**
  - The Combinatorial Sealed Bid Auction is the most complex and highest risk auction format. There is a risk of bad outcomes: regional bidders being excluded from the C Band, unsold licenses, etc.

Table of Contents

Section 1: Introduction and Key Findings

C-Band Alliance FUEL Auction Proposal

- The C-Band Alliance (CBA) – formed by C Band Satellite Operators – has as its mission the repurposing of spectrum in the 3700-4200 MHz range from satellite use to terrestrial:
  - This Mid-Band C Band spectrum is a key strategic building block of 5G globally.
  - The 3700-4200 MHz range sits just above the US CBRS range 3550-3700 MHz (LTE Band 48)
  - The range forms part of the international allocation for 5G: 3300-4200 MHz (LTE Band n77).
- The CBA has been working towards conducting a private auction for 180 MHz of its spectrum packaged as 9 blocks of 20 MHz (plus 20 MHz of guard band).
  - NOTE: Comments on format are independent of whether a private auction or an FCC-run auction.
- On June 12, 2019 the CBA filed *ex parte* with the FCC a White Paper by Auctionomics, "FUEL for 5G: Flexible Use and Efficient Licensing" in which it proposes a Combinatorial Sealed Bid format for the private auction.
- This presentation provides our comments on the FUEL auction format as proposed.
  - **NOTE**: LYA's comments are based on experience supporting bidders in spectrum auctions with different formats, and development of software with full implementation of rule sets for mock auctions and simulations. This includes implementation of winner determination and pricing algorithms for combinatorial auctions, and development of AI bidders to bid into different formats for auction simulation.

FUEL Auction Process Overview

- Allocation Stage:

Two-Round Structure

1. **Coordination round**, optional for bidders, in which bidders may submit bids for packages of licenses at prices prescribed in advance. The packages bid in the coordination round are revealed to all bidders before the main bidding round.

2. **Main Bidding round,** in which bidders submit *bid groups* according to the FUEL design. Each bid group consists of a base bid and adjustments, at prices the bidders themselves select.

➤Bids in both rounds are used in winner and price determination

- Assignment Stage:
  - The subsequent *assignment stage* will give bidders the opportunity to place additional bids to be awarded preferred frequencies within the band.
    - Following best practice in spectrum auctions, bidders that win multiple early blocks or multiple later blocks in the allocation stage are guaranteed to have their corresponding frequencies adjacent within a given PEA; there may also be some limited guarantee of adjacency across PEAs.

Source: White Paper Overview, The FUEL Auction Design, Auctionomics, June 2019, page 12 (ex parte filing June 10, 2019)

No Evidence FUEL Would be Any Quicker

Per Auctionomics presentation filed June 10, 2019 (p 21):

- Sealed bids require much less time for bidder training
- Second-price sealed-bids require less bid preparation time
- FUEL reduces data entry, making bidding easier and reducing the chance of bidder error
- Auction takes only 2–4 weeks (or less) to run
- 5G spectrum available within 18 months of final order

Auction Duration - Weeks	Clock Auctions	
	Auction 102 - 24 GHz (2019) - 91 Rounds	Forward Auction Stage 4 - 600 MHz (2017) - 58 Rounds
Clock Rounds	5.0	3.0
Break	2.0	3.0
Assignment Rounds	4.0	3.0
Total weeks	11.0	9.0

Well-established auction formats with price discovery can be quick and efficient. There is no need to adopt a new risky format to save a week or two.

Auction Formats

- The Combinatorial Sealed Bid auction, as proposed for FUEL, is **not** a widely used format – it should not be confused with the Combinatorial Clock Auction (CCA).
  - CCA auctions have been employed, starting in 2008 in the UK, and subsequently many other countries, including Switzerland, Canada, Australia and others.
  - To our knowledge, the CCA auction conducted with the largest number of items for sale was held in Canada in 2015 for 2500 MHz licenses with 58 geographic areas.
  - Auctionomics at page 2: The "advantages of package auctions have contributed to the popularity of the combinatorial clock auction design (CCA) in many countries around the world." But there is little resemblance of FUEL with the overall CCA process.
- And there is now a trend away from Combinatorial Auctions…
  - UK Ofcom: "In choosing an SMRA format, we noted that it would be less complicated, more transparent and would be likely to generate fewer difficulties for bidders in dealing with their internal governance than the CCA alternative." Statement 2.3/3.4 GHz Auction, 2018, par. 26
  - Canada ISED 3.5 GHz auction (2020) with 172 license areas: "…the number of licenses and products that will be available for the 3500 MHz auction significantly exceeds the number of licenses available in previous Canadian CCA auctions. This would introduce the **computational risks** to using the CCA format." SLPB-002-19, 2019, par. 65 (**emphasis** added)
- A non-combinatorial Clock Auction process – price discovery rounds with bidding on generic blocks, followed by an assignment phase to award specific frequencies – would be much simpler and less prone to error.

References: Price Discovery Rounds

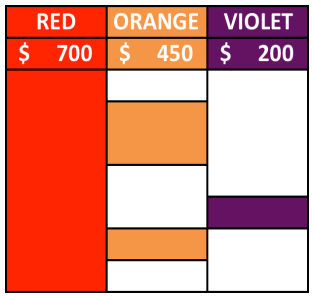
- Origins of Combinatorial Clock Auction – UK, 2008:
  - The Combinatorial Clock Auction *…allows package bids but retains the simple price discovery of the [Simultaneous Multiple Round] auction by starting with an initial clock stage where bidders express their demand for licenses as the auctioneer raises prices.*
  - Source: Using Spectrum Auctions to Enhance Competition in Wireless Services, SIEPR Discussion Paper No. 10-015, Peter Cramton, Evan Kwerel, Gregory Rosston, and Andrzej Skrzypacz, February 2011, page 14
- Price discovery is an important element of any auction:
  - *The Clock Phase provides price discovery that the bidders can use to guide their calculations in the complex package auction. At each round, bidders are faced with the simple and familiar problem of expressing demands at specified prices… As the bidding continues, bidders get a better understanding of what they may win and where their best opportunities lie.*
  - Source: The Clock-Proxy Auction: A Practical Combinatorial Auction Design, Lawrence Ausubel, Peter Cramton and Paul Milgrom, Chapter 5 of Combinatorial Auctions, MIT Press, 2006, page 128
- An auction with no price discovery comes with significant risks:
  - *Auction formats that limit price discovery can mean operators are forced to bid blindly and risk overpaying or not getting spectrum.* Source: Spectrum Pricing – GSMA Public Policy Position, Sept 2017, page 5

LYA's experience with Combinatorial Sealed Bid Auctions – i.e. where there are no price discovery rounds – highlights the risk of mobile carriers not obtaining spectrum where they need it.

FUEL is a High Risk Bidding Format

- Threshold issues for non-national bidders;
- Exposure Risk;
- Specification Problems;
- Bid Collections that have Implied Bids;
- Format prone to gaming and strategic bidding;
- As discussed on the following pages.

FUEL Threshold Issue – Package Bids by EA



EA064	Market
PEA003	Chicago
PEA116	Rockford IL
PEA224	De Kalb, IL
PEA270	Ottawa IL
PEA273	Bloomington IL
PEA287	Kenosha WI
PEA353	Watseka IL

EA104	Market
PEA122	Madison WI
PEA223	Dubuque IA
PEA253	Baraboo WI
PEA384	Manchester IA

EA003	Market
PEA007	Boston MA
PEA060	Manchester NH
PEA143	Keene NH

EA124	Market
PEA063	Tulsa OK
PEA278	Bartlesville OK
PEA281	Muskogee OK
PEA295	Stillwater OK

- **FUEL Auction** – **RED** wins all of the licenses in EA 064. **ORANGE** and **VIOLET** would have to collectively have bid >$700 to win their markets, essentially bidding to include the price of Chicago (a large expensive market) in order to beat **RED**.
- **ORANGE** and **VIOLET** cannot bid above the "threshold" to win over **RED**. There is only one possible outcome.
- The same issue will apply in many EA's due to the very high value of one particular large market compared to smaller markets included in the same EA. Small bidders will only win in a if their bids either fit in with the bids of the large bidders or can be combined to outweigh the larger bids.
- And this threshold problem is further magnified in the FUEL auction if large bidders place national bids with increments. Small bidders will only win if their packages fit with the those of the larger bidders or if the packages demanded by the large bidders are mutually incompatible.

FUEL Exposure Risk Bidding on Multiple EA's

EA064	Market
PEA003	Chicago
PEA116	Rockford IL
PEA224	De Kalb, IL
PEA270	Ottawa IL
PEA273	Bloomington IL
PEA287	Kenosha WI
PEA353	Watseka IL

Complements

EA104	Market
PEA122	Madison WI
PEA223	Dubuque IA
PEA253	Baraboo WI
PEA384	Manchester IA

EA003	Market
PEA007	Boston MA
PEA060	Manchester NH
PEA143	Keene NH

EA124	Market
PEA063	Tulsa OK
PEA278	Bartlesville OK
PEA281	Muskogee OK
PEA295	Stillwater OK

- EA's 064 and 104 are geographically contiguous and ORANGE operates in both. These PEA's are complementary. ORANGE would like to create a bid that adds value to combinations of adjacent markets that are in different EA's.
  - Also, smaller PEA's are likely worth less on their own than if combined with the larger PEA's – e.g. Madison may have lower value if not won along with Kenosha and De Kalb.
- **FUEL Auction**: ORANGE cannot specify the value of a package of PEA Madison, Kenosha and De Kalb, etc. ORANGE has to bid high value and/or bid for non-desired markets in order to win over someone bidding on entire EA's. It is "exposed" to winning an undesirable package or not winning at all.
- In a Clock Auction ORANGE can manage exposure risk by adjusting demand round by round. Other rules in FCC auctions – e.g. activity rules – also help mitigate risk of acquiring less desirable licenses.

FUEL Specification Problem for Substitutes

EA064	Market
PEA003	Chicago
PEA116	Rockford IL
PEA224	De Kalb, IL
PEA270	Ottawa IL
PEA273	Bloomington IL
PEA287	Kenosha WI
PEA353	Watseka IL

EA104	Market
PEA122	Madison WI
PEA223	Dubuque IA
PEA253	Baraboo WI
PEA384	Manchester IA

EA003	Market
PEA007	Boston MA
PEA060	Manchester NH
PEA143	Keene NH

Substitutes

EA124	Market
PEA063	Tulsa OK
PEA278	Bartlesville OK
PEA281	Muskogee OK
PEA295	Stillwater OK

- **FUEL Auction: VIOLET** cannot specify that it would like Manchester **or** Tulsa, but not both. The two are substitutes. **VIOLET's** strategy is thus to bid on both even though it does not want to win both.
  - Also **VIOLET** cannot express the lower value of Keene NH if won without winning the adjacent larger market, Manchester NH.

- In a Clock Auction **VIOLET** can switch demand from Manchester to Tulsa as rounds progress – i.e. if one increases rapidly, it switches to the other, and may later switch back. This phenomenon can be seen in FCC auction bidding, indicating that some markets are considered substitutes. Also, as with exposure risk, other rules in FCC auctions – e.g. activity rules – help mitigate the risk of acquiring less-desirable licenses.

FUEL Bid Groups – Cannot Fully Specify Values

	Number of Licenses				
PEA	**0**	**1**	**2**	**3**	**4**
A*			Base	$10	$15
B			Base	$20	
C*	$–15		Base	$5	
Base price:	**$200**	**EARLY/MIXED BID GROUP**			

- FUEL Bid Group Example at page 9 – specifies collections of licenses representing 18 packages, **that are implied by the bid group.** For example:
  - The "base bid" is $200 for two blocks in each PEA.
  - Another bid is $210 for three blocks in PEA A and two in each of PEA B and C,
  - Another bid is $220 for two blocks in PEA A and C and three in PEA B, etc.
- This bidding "language" does not allow a bidder to fully express its valuation function. This can lead to a bidder making many errors in bidding. For example:
  - One of the packages is a bid of $215 for 4 blocks in PEA A and two in each of PEA B and C. But the bidder may have preferred to indicate it would take two additional blocks in PEA A for $15 if and only if it can have two less in PEA C (i.e. 0 blocks for $15 less), at the same bid value of $200. There is no way to make that distinction within one bid group.
  - The collection implies a max bid of $240 – 4 blocks in PEA A and three in each of PEA B and C. This may be an undesirable package and may be over budget. The bid is placed automatically. The bidder cannot exclude undesirable combinations from the collection.
- Placing bids explicitly is less error prone and clearer for bidders.
  - Was part of the rules of Canadian 2500 MHz auction in 2015; was not extensively used.

FUEL Gaming Incentives

- Large bidders can bid in a way to game the bid collections and directly impact smaller, regional bidders:
  - The Auctionomics example (FUEL White Paper Appendix) shows how bid shading – non-truthful bidding – can eliminate a regional bidder,
  - Large bidders can also simply bid without leaving room for regional bidders. What is the incentive to "play nice"?
- With the FUEL bidding language, one bid could be placed for all 9 blocks at a very high price to win over all other bids, creating an auction outcome with only one bidder.
  - Bidders in a Clock or SMRA auction may also bid for all items, but with multiple rounds are likely to end up with a subset.
  - With FUEL a large 9 block bid can be treated as all-or-nothing, so losing is costless and winning would have high foreclosure value. Bidders could also use this mechanism to create large losing bids with the sole purpose of influencing prices of other bidders.
- There are other examples of gaming incentives that are built into FUEL:
  - Coordination round – little incentive to participate other than to mislead. Auctionomics at page 7 states: "Some bidders, especially smaller ones, may wish to use the Coordination round to advertise their preferred packages…". Unclear why a bidder in any auction would want to "advertise" what it wants. In any case, the operating areas of small and regional bidders in the US are already well-known.
  - Definition of large "national" bids versus small bids – these are based on the size of the bid not on the size of the bidder. Any bidder could create large non-winning bids which would serve only to influence prices of other bidders. Bidders may place both large all-or-nothing bids as well as EA-constrained small bids.
  - The second price mechanism incents bidders to focus on values of the other bidders to place bids to influence prices.

Key Conclusions

- A Combinatorial Sealed Bid format is inadequate; the **auction must have price discovery rounds:**
  - Bidders need to be able to adjust targets as rounds progress instead of just taking risky "shots in the dark". Price discovery is a dynamic process, allows bidders to focus attention on where the best opportunities lie -- *this is necessary as the number of bidding options is vey large in spectrum auctions*.
  - A multi-round auction also increases likelihood of all licenses being sold; a better market outcome,
  - High risk for non-national "bids" due to winner determination by EA – issue for both small and large "bidders", but particularly biased against smaller and regional bidders.
- Bidding with "bid groups" (series of Exclusive-Or bids) **increases risks** with no benefit:
  - Cannot adequately specify valuation function – assumes valuations are all additive,
  - Collections are for "implied bids" – it is better for bidders to express demand on specific packages – bidders do not have 10^{406} possible objectives. Highly prone to error.
- **Competitive measures** are needed in combinatorial auctions because of the threshold problem – e.g. a spectrum cap and/or reserve blocks.
- The FUEL auction is complex for bidders and there is no evidence that it would be any quicker to implement than the well-known Clock Auction process. In any case the time required to run auctions with other formats is not a key factor, particularly for a strategically important 5G band.
- Band Plan with blocks of 20 MHz is restrictive – could use blocks of 5 MHz or 10 MHz instead, which would align well with 5G band plans in other countries.
- A better mechanism could be a non-combinatorial Clock Auction with blocks in categories:
  - This is no more complex than Auction 1002 (Forward Auction) or Auction 102 (24 GHz).
  - The Combinatorial Sealed Bid Auction is the most complex and highest risk auction format.

Table of Contents

Section 2: Overall Comments on the Proposed FUEL Format

FUEL Auction Process Overview

- Allocation Stage:

Two-Round Structure

1. **Coordination round**, optional for bidders, in which bidders may submit bids for packages of licenses at prices prescribed in advance. The packages bid in the coordination round are revealed to all bidders before the main bidding round.

2. **Main Bidding round,** in which bidders submit *bid groups* according to the FUEL design. Each bid group consists of a base bid and adjustments, at prices the bidders themselves select.

➤Bids in both rounds are used in winner and price determination

- Assignment Stage:
  - The subsequent *assignment stage* will give bidders the opportunity to place additional bids to be awarded preferred frequencies within the band.
    - Following best practice in spectrum auctions, bidders that win multiple early blocks or multiple later blocks in the allocation stage are guaranteed to have their corresponding frequencies adjacent within a given PEA; there may also be some limited guarantee of adjacency across PEAs.

Source: White Paper Overview, The FUEL Auction Design, Auctionomics, June 2019, page 12 (ex parte filing June 10, 2019)

The FUEL Auction Process

- FUEL is proposed to have two sealed bid rounds where bidders place multiple bids followed by winner determination.
- The FUEL auction would be for nine blocks in each of 406 PEA's.
- The FUEL White Paper does not provide any detail on the proposed process to solve the FUEL auction. Many bidding rules and constraints are missing from the FUEL paper.
  - There are myriad combinations of bids possible across 406 PEAs: large and small bids, early and late spectrum, increments and decrements by PEA, and large "national" all-or-nothing bids. The auction would be very complicated, more complex than a CCA auction, and could therefore be extremely difficult to solve or not solvable at all; the exact rules and constraints need to be known. No practical solution is shown. The lack of structure brought by price discovery increases the range of admissible bids, making solving the winner determination problem even more complex.
- The FUEL paper does not indicate if all bids are processed together (base bids including increments/decrements) or if winner determination is solved in steps (find winning base bids first then solve for the increments/decrements).
- The outcome of the FUEL auction would be highly dependent on how the auction is solved:
  - **OPTION 1**: Consider all base bids first. Large base bids win and small bidders will pick up the remaining licenses and some licenses may remain unsold.
  - **OPTION 2**: Consider all bids together, including increments/decrements. Outcome: large bidders split the nine licenses and no small bidders will win anything.
- And regardless how it is solved, there is a high risk to small bidders in not being able to win spectrum at all.

Small/Regional Bidders May Be Unable to Win

- Consider two large bidders and 5 PEA's: bidders **RED** and **BLUE** both target all PEA's.
  - There are nine blocks available in each PEA; both bidders place a large package bid for 5 blocks in all five PEA's and a decrement of one block in all five PEA's in order to try to win all 9 blocks. **RED** also places a decrement bid of two blocks.
  - A regional bidder targets 2 blocks in each PEA, and puts a decrement bid of 1 block.
  - All bidders have a base value $10 per block and valuations are additive (so 5 blocks = 5x $10), etc.

RED BIDDER			
PEA	MHz and Quantity of Blocks		
	60 MHz	80 MHz	100 MHz
	3	4	5
1	$ (40)	$ (20)	base
2	$ (40)	$ (20)	base
3	$ (40)	$ (20)	base
4	$ (40)	$ (20)	base
5	$ (40)	$ (20)	base
Base price	***$ 250***		
4 block price	*$ 150*		
3 block price	*$ 50*		

BLUE BIDDER		
PEA	MHz and Quantity of Blocks	
	80 MHz	100 MHz
	4	5
1	$ (20)	base
2	$ (20)	base
3	$ (20)	base
4	$ (20)	base
5	$ (20)	base
Base price	***$ 250***	
4 block price	*$ 150*	

REGIONAL GREEN BIDDER		
PEA	MHz and Quantity of Blocks	
	20 MHz	40 MHz
	1	2
1		
2	$ (10)	base
3	$ (10)	base
4		
5		
Base price	***$40***	
1 block price	*$20*	

- Assuming the FUEL auction considers all of these bids, the regional bidder cannot realistically win.
  - The outcome will be nine blocks to **RED** and **BLUE** for $400. For the regional bidder to win anything it needs to bid over 2x its valuation. Instead of bidding $40, it would have to bid over $80 in order to win.
  - The use of the decrement features by large bidders can result in ensuring that no regional bidders win (by bidding a decrement that is higher than their valuation).
- Small bidders only win when they fit into the large bids or if the large bids are mutually exclusive. In fact it is easier for the package bids of the large bidder to fit together and thus harder for the package bids of the smaller bidders to win.

One Bidder Bids All 9 Blocks

- As currently proposed, the FUEL auction has no "rules" – no eligibility point system, no spectrum caps or reserve blocks, no limit on number of bids that can be placed (but Auctionomics says there will be a limit), no identified limit on types of bids that can be specified (i.e. relative to the 10^{406} combinations), etc.
- To win the FUEL auction, then, a bidder places a very large bid for all nine blocks (180 MHz), all or nothing. There is little downside:
  - If the bid loses, the bidder wins nothing and pays nothing, unlike an item auction where a bidder can win a portion of the package bid, and,
  - If the bid wins, then the bidder will pay the opportunity cost second price for the licenses, which could be at a significant discount.

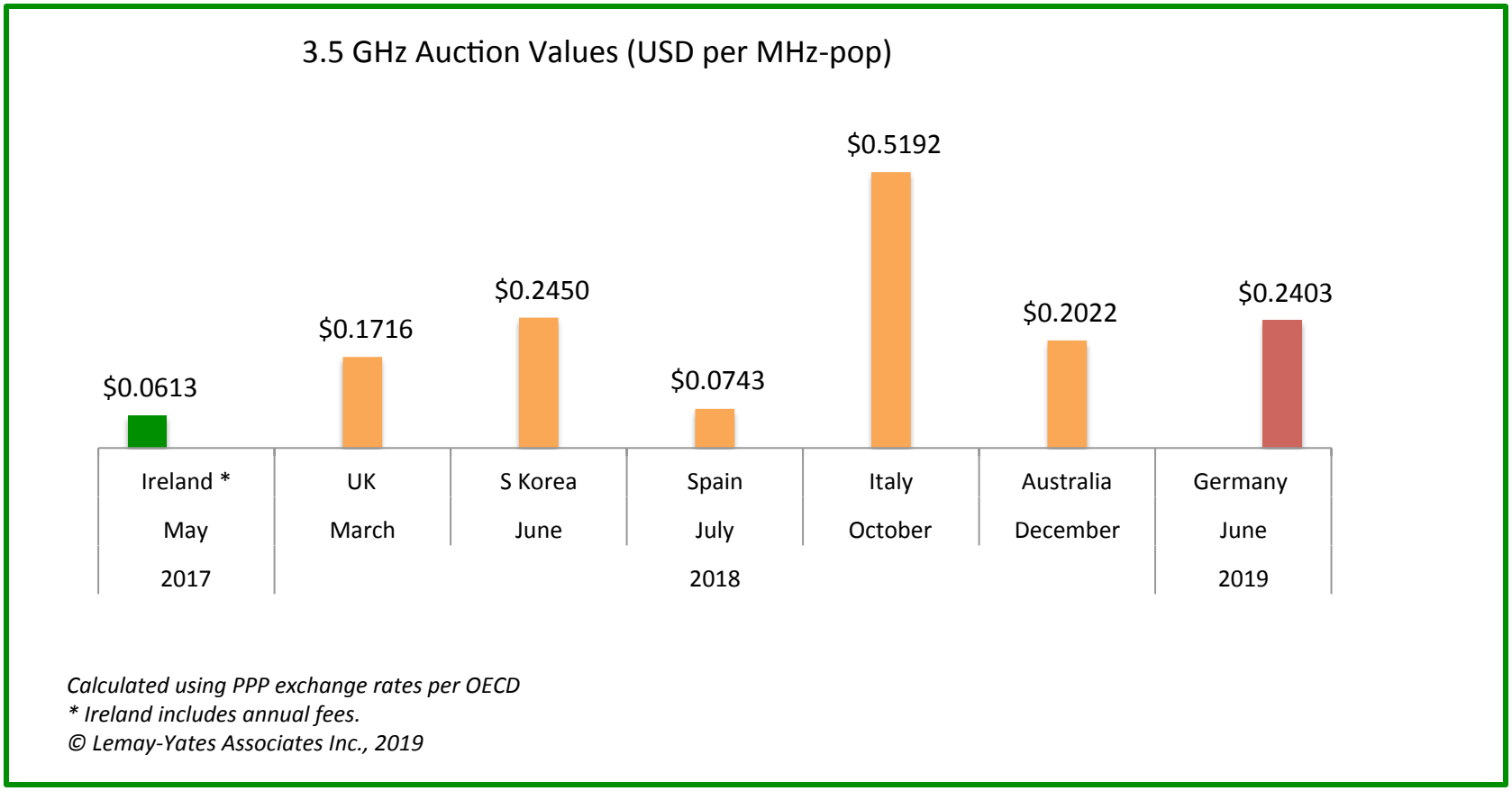
- **Would this represent a successful outcome?**

EXAMPLE WINNING BID		
PEA	Quantity of Blocks	
	8	9
1		base
2		base
3		base
4		base
5		base
etc.		
Base price	***very large $ value***	

Pricing and International Benchmarks

- Auctionomics at page 11 suggests an "aggregate" reserve bid could be set based on international $/MHz-pop benchmarks.
  - Most international auctions have been first price auctions and values have increased dramatically (see next page).
  - So these benchmarks are the current market price and not the opening bids from those auctions. The C Band auction should use an auction mechanism to find the correct price in the US. The FUEL auction would have no price discovery rounds that would do that.
- Further, the FUEL auction would award licenses on the basis of the best "second price"… but bidders have to be prepared to pay as-bid prices (or very close to as-bid).
  - A bidder's winning price is entirely dependent on the bids placed by the other bidders (but capped at as-bid).
  - This is the case in the FUEL auction where bidders may put in extensive collections with increments and decrements, erasing second price discounts particularly for smaller bidders.
- Setting reserve prices at international benchmarks therefore further biases outcomes.

International Benchmarks



- Considering benchmarks of Germany and Italy, auction reserve would range from $13 billion to $29 billion.
- And could be higher if bidding increases values from reserve.

Table of Contents

Section 3: No Evidence FUEL Would be Any Quicker

No Evidence FUEL Would be Any Quicker

Per Auctionomics presentation filed June 10, 2019 (p 21):

- Sealed bids require much less time for bidder training
- Second-price sealed-bids require less bid preparation time
- FUEL reduces data entry, making bidding easier and reducing the chance of bidder error
- Auction takes only 2–4 weeks (or less) to run
- 5G spectrum available within 18 months of final order

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- 5G spectrum available within 18 months of final order

Not True: Winner determination and pricing is complex and opaque; results are counter-intuitive. Recognized governance issue in second-price combinatorial auctions increases risks for all bidders.

No Evidence FUEL Would be Any Quicker

Per Auctionomics presentation filed June 10, 2019 (p 21):

- Sealed bids require much less time for bidder training
- Second-price sealed-bids require less bid preparation time
- FUEL reduces data entry, making bidding easier and reducing the chance of bidder error
- Auction takes only 2–4 weeks (or less) to run
- 5G spectrum available within 18 months of final order

Not True: Bidders need to spend considerable effort and time on assessing all possible valuations of their competitors. The only certainty is that this assessment will mostly be wrong. Requires much more preparation since no chance to adjust during price discovery – "shooting in the dark".

No Evidence FUEL Would be Any Quicker

Per Auctionomics presentation filed June 10, 2019 (p 21):

- Sealed bids require much less time for bidder training
- Second-price sealed-bids require less bid preparation time
- FUEL reduces data entry, making bidding easier and reducing the chance of bidder error
- Auction takes only 2–4 weeks (or less) to run
- 5G spectrum available within 18 months of final order

Not True: Cannot fully specify valuation function using incremental bids – easy to make errors with implied bids.

No Evidence FUEL Would be Any Quicker

Per Auctionomics presentation filed June 10, 2019 (p 21):

- Sealed bids require much less time for bidder training
- Second-price sealed-bids require less bid preparation time
- FUEL reduces data entry, making bidding easier and reducing the chance of bidder error
- Auction takes only 2–4 weeks (or less) to run
- 5G spectrum available within 18 months of final order

Auction Duration - Weeks	Clock Auctions	
	Auction 102 - 24 GHz (2019) - 91 Rounds	Forward Auction Stage 4 - 600 MHz (2017) - 58 Rounds
Clock Rounds	5.0	3.0
Break	2.0	3.0
Assignment Rounds	4.0	3.0
Total weeks	11.0	9.0

Well-established auction formats with price discovery can be quick and efficient. There is no need to adopt a new risky format to save a week or two.

No Evidence FUEL Would be Any Quicker

Per Auctionomics presentation filed June 10, 2019 (p 21):

- Sealed bids require much less time for bidder training
- Second-price sealed-bids require less bid preparation time
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- Auction takes only 2–4 weeks (or less) to run
- 5G spectrum available within 18 months of final order

Not directly related to auction process.

There is <u>no</u> evidence that the FUEL Auction would be any quicker than a Clock Auction with price discovery.

Table of Contents

Section 4: Combinatorial Sealed Bid Format Not Suitable – Need Price Discovery

Auction Formats

- The Combinatorial Sealed Bid auction, as proposed for FUEL, is **not** a widely used format – it should not be confused with the Combinatorial Clock Auction (CCA).
  - CCA auctions have been employed, starting in 2008 in the UK, and subsequently many other countries, including Switzerland, Canada, Australia and others.
  - To our knowledge, the CCA auction conducted with the largest number of items for sale was held in Canada in 2015 for 2500 MHz licenses with 58 geographic areas.
  - Auctionomics at page 2: The "advantages of package auctions have contributed to the popularity of the combinatorial clock auction design (CCA) in many countries around the world." But there is little resemblance of FUEL with the overall CCA process.
- And there is now a trend away from Combinatorial Auctions…
  - UK Ofcom: "In choosing an SMRA format, we noted that it would be less complicated, more transparent and would be likely to generate fewer difficulties for bidders in dealing with their internal governance than the CCA alternative." Statement 2.3/3.4 GHz Auction, 2018, par. 26
  - Canada ISED 3.5 GHz auction (2020) with 172 license areas: "…the number of licenses and products that will be available for the 3500 MHz auction significantly exceeds the number of licenses available in previous Canadian CCA auctions. This would introduce the **computational risks** to using the CCA format." SLPB-002-19, 2019, par. 65 (**emphasis** added)
- A non-combinatorial Clock Auction process – price discovery rounds with bidding on generic blocks, followed by an assignment phase to award specific frequencies – would be much simpler and less prone to error.

FUEL Compared to the Clock Auction

- The FCC Clock Auction process progresses through multiple bidding rounds until the market clearing price is found – bidders pay as-bid.

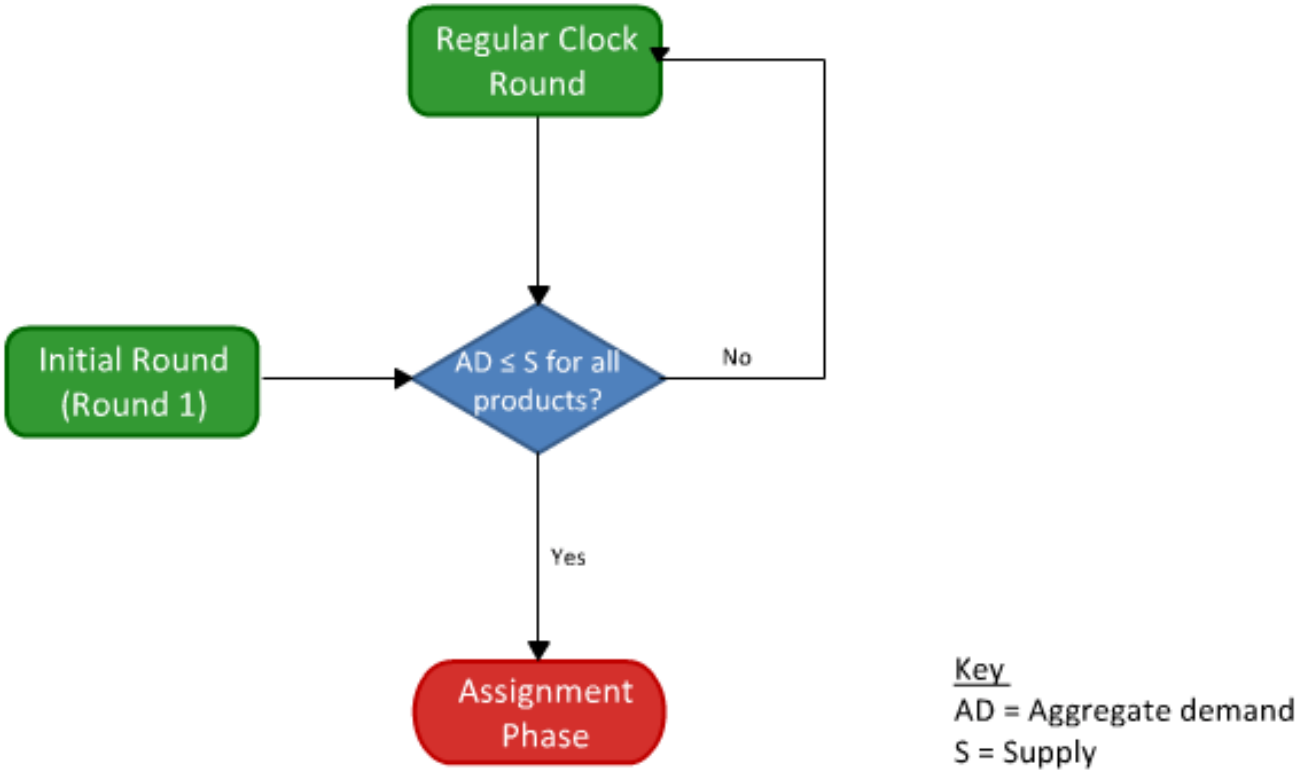
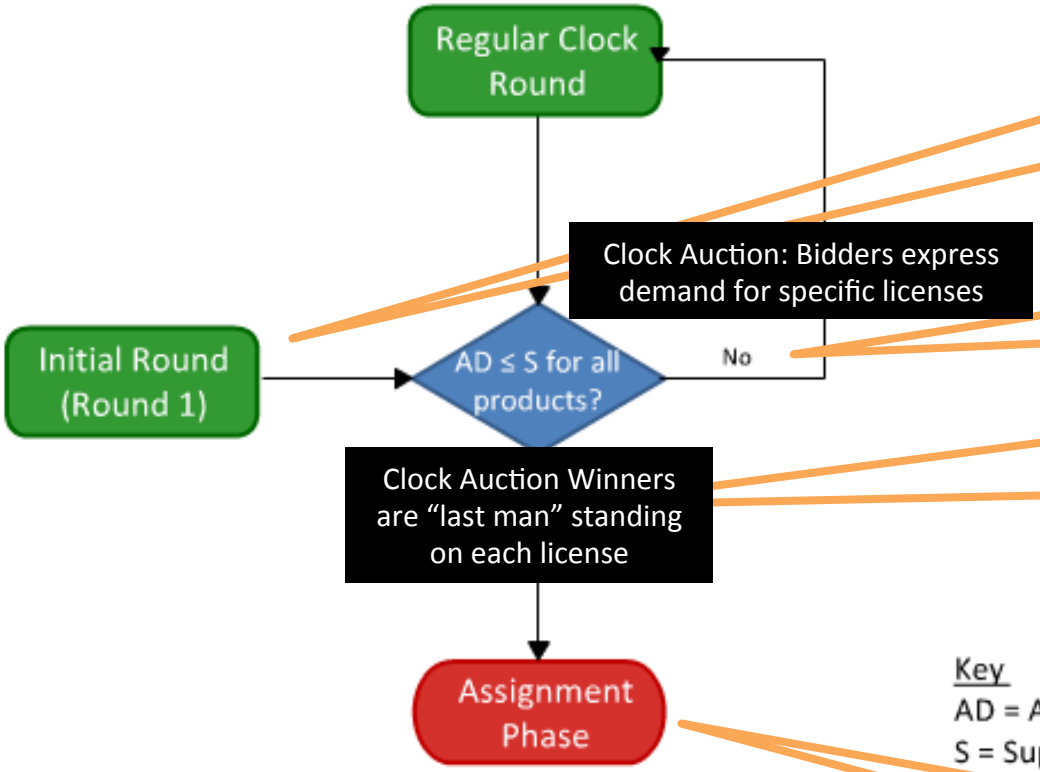


Figure: Auction Flow per FCC, 24 GHz Clock Phase Tutorial

FUEL Compared to the Clock Auction

- The FCC Clock Auction process progresses through multiple bidding rounds until the market clearing price is found – bidders pay as-bid.



Key
AD = Aggregate demand
S = Supply

FUEL – No Price Discovery Rounds – Reserve bids to be based on international benchmarks

FUEL – Sealed Bids are placed using "collections" that cannot fully specify valuations

FUEL – Winner determination on two classes of bid: national with all-or-nothing feature; increased exposure risk for non-national bids placed EA by EA

FUEL – Assignment Stage likely much the same as in a Clock Auction

Figure: Auction Flow per FCC, 24 GHz Clock Phase Tutorial

References: Need for Price Discovery Rounds

- Origins of Combinatorial Clock Auction – UK, 2008:
  - The Auction *…allows package bids but retains the simple price discovery of the [Simultaneous Multiple Round] auction by starting with an initial clock stage where bidders express their demand for licenses as the auctioneer raises prices.*
  - Source: Using Spectrum Auctions to Enhance Competition in Wireless Services, SIEPR Discussion Paper No. 10-015, Peter Cramton, Evan Kwerel, Gregory Rosston, and Andrzej Skrzypacz, February 2011, page 14
- Price discovery is an important element of any auction:
  - *The Clock Phase provides price discovery that the bidders can use to guide their calculations in the complex package auction. At each round, bidders are faced with the simple and familiar problem of expressing demands at specified prices… As the bidding continues, bidders get a better understanding of what they may win and where their best opportunities lie.*
  - Source: The Clock-Proxy Auction: A Practical Combinatorial Auction Design, Lawrence Ausubel, Peter Cramton and Paul Milgrom, Chapter 5 of Combinatorial Auctions, MIT Press, 2006, page 128
- An auction with no price discovery comes with significant risks:
  - *Auction formats that limit price discovery can mean operators are forced to bid blindly and risk overpaying or not getting spectrum.* Source: Spectrum Pricing – GSMA Public Policy Position, Sept 2017, page 5

LYA's experience with Combinatorial Sealed Bid Auctions – i.e. where there are no price discovery rounds – highlights the risk of mobile carriers not obtaining spectrum where they need it.

Combinatorial Sealed Bid Format Is Not Suitable

- Auctionomics at page 2 suggests that: *…package auctions improve efficiency by avoiding the "exposure problem" associated with the FCC's traditional auction designs in which bids for each PEA are separate.*
- **This is not the case for the FUEL auction**. There are many risks, particularly for non-National bids (that may be placed by small or large bidders). Issues are present primarily due to the lack of price discovery rounds:
  - Threshold Issues, resulting in smaller bidders winning nothing.
  - Exposure Risk for bidders: require bidders to bid higher on less desirable markets to ensure winning adjacent areas.
  - Specification Problems, requiring bidders to bid on sets of markets that are alternatives to each other, and risk winning both.
  - Potentially unsold licenses and resultant low revenues.
- This section provides an example of problems with the Combinatorial Sealed Bid Auctions where winner determination is done by groups of licenses (in the case of FUEL, by EA **for non-National bids**).
  - A recent Canadian Auction ("Residual Auction" held in 2018) had all of these problems. The example is built on LYA's experience in that auction as well as previous Sealed Bid and Combinatorial Clock Auctions.

Combinatorial Sealed Bid Example

EA064	Market
PEA003	Chicago
PEA116	Rockford IL
PEA224	De Kalb, IL
PEA270	Ottawa IL
PEA273	Bloomington IL
PEA287	Kenosha WI
PEA353	Watseka IL

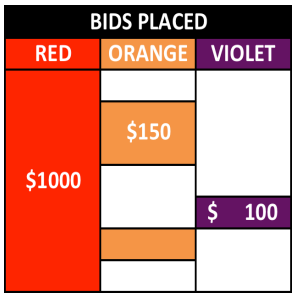
EA104	Market
PEA122	Madison WI
PEA223	Dubuque IA
PEA253	Baraboo WI
PEA384	Manchester IA

EA003	Market
PEA007	Boston MA
PEA060	Manchester NH
PEA143	Keene NH

EA124	Market
PEA063	Tulsa OK
PEA278	Bartlesville OK
PEA281	Muskogee OK
PEA295	Stillwater OK

- Consider a set of four EA's – EA 003, 064, 103 and 124
- Together these four EA's account for 18 PEA's.
- Bids are placed by EA (i.e. as is the case for FUEL for non-national bids).
- For simplicity consider one license available per PEA.
- There are three bidders: large national bidder **RED**, and two regional bidders **ORANGE**, **VIOLET.**

FUEL Threshold Issue – Package Bids by EA



EA064	Market
PEA003	Chicago
PEA116	Rockford IL
PEA224	De Kalb, IL
PEA270	Ottawa IL
PEA273	Bloomington IL
PEA287	Kenosha WI
PEA353	Watseka IL

EA104	Market
PEA122	Madison WI
PEA223	Dubuque IA
PEA253	Baraboo WI
PEA384	Manchester IA

EA003	Market
PEA007	Boston MA
PEA060	Manchester NH
PEA143	Keene NH

EA124	Market
PEA063	Tulsa OK
PEA278	Bartlesville OK
PEA281	Muskogee OK
PEA295	Stillwater OK

- **FUEL Auction** – **RED** wins all of the licenses in EA 064. **ORANGE** and **VIOLET** would have to collectively have bid >$1,000 to win their markets, essentially bidding to include the price of Chicago (a large expensive market) in order to beat **RED**.
- **ORANGE** and **VIOLET** cannot bid above the "threshold" to win over **RED**. There is only one possible outcome.
- The same issue will apply in many EA's due to the very high value of one particular large market compared to smaller markets included in the same EA. Small bidders will only win in a if their bids either fit in with the bids of the large bidders or can be combined to outweigh the larger bids.
- And this threshold problem is further magnified in the FUEL auction if large bidders place national bids with increments. Small bidders will only win if their packages fit with the those of the larger bidders or if the packages demanded by the large bidders are mutually incompatible.

FUEL Exposure Risk Bidding on Multiple EA's

EA064	Market
PEA003	Chicago
PEA116	Rockford IL
PEA224	De Kalb, IL
PEA270	Ottawa IL
PEA273	Bloomington IL
PEA287	Kenosha WI
PEA353	Watseka IL

Complements

EA104	Market
PEA122	Madison WI
PEA223	Dubuque IA
PEA253	Baraboo WI
PEA384	Manchester IA

EA003	Market
PEA007	Boston MA
PEA060	Manchester NH
PEA143	Keene NH

EA124	Market
PEA063	Tulsa OK
PEA278	Bartlesville OK
PEA281	Muskogee OK
PEA295	Stillwater OK

- EA's 064 and 104 are geographically contiguous and ORANGE operates in both. These PEA's are complementary. ORANGE would like to create a bid that adds value to combinations of adjacent markets that are in different EA's.
  - Also, smaller PEA's are likely worth less on their own than if combined with the larger PEA's – e.g. Madison may have lower value if not won along with Kenosha and De Kalb.
- **FUEL Auction**: ORANGE cannot specify the value of a package of PEA Madison, Kenosha and De Kalb, etc. ORANGE has to bid high value and/or bid for non-desired markets in order to win over someone bidding on entire EA's. It is "exposed" to winning an undesirable package or not winning at all.
- In a Clock Auction ORANGE can manage exposure risk by adjusting demand round by round. Other rules in FCC auctions – e.g. activity rules – also help mitigate risk of acquiring less desirable licenses.

FUEL Specification Problem for Substitutes

EA064	Market
PEA003	Chicago
PEA116	Rockford IL
PEA224	De Kalb, IL
PEA270	Ottawa IL
PEA273	Bloomington IL
PEA287	Kenosha WI
PEA353	Watseka IL

EA104	Market
PEA122	Madison WI
PEA223	Dubuque IA
PEA253	Baraboo WI
PEA384	Manchester IA

EA003	Market
PEA007	Boston MA
PEA060	Manchester NH
PEA143	Keene NH

Substitutes

EA124	Market
PEA063	Tulsa OK
PEA278	Bartlesville OK
PEA281	Muskogee OK
PEA295	Stillwater OK

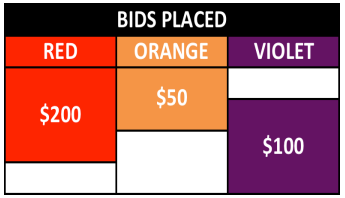
- **FUEL Auction: VIOLET** cannot specify that it would like Manchester **or** Tulsa, but not both. The two are substitutes. **VIOLET's** strategy is thus to bid on both even though it does not want to win both.
  - Also **VIOLET** cannot express the lower value of Keene NH if won without winning the adjacent larger market, Manchester NH.

- In a Clock Auction **VIOLET** can switch demand from Manchester to Tulsa as rounds progress – i.e. if one increases rapidly, it switches to the other, and may later switch back. This phenomenon can be seen in FCC auction bidding, indicating that some markets are considered substitutes. Also, as with exposure risk, other rules in FCC auctions – e.g. activity rules – help mitigate the risk of acquiring less-desirable licenses.

FUEL Auction Potential for Unsold

EA064	Market
PEA003	Chicago
PEA116	Rockford IL
PEA224	De Kalb, IL
PEA270	Ottawa IL
PEA273	Bloomington IL
PEA287	Kenosha WI
PEA353	Watseka IL

EA104	Market
PEA122	Madison WI
PEA223	Dubuque IA
PEA253	Baraboo WI
PEA384	Manchester IA



EA003	Market
PEA007	Boston MA
PEA060	Manchester NH
PEA143	Keene NH

EA124	Market
PEA063	Tulsa OK
PEA278	Bartlesville OK
PEA281	Muskogee OK
PEA295	Stillwater OK

- **FUEL Auction** – ORANGE and VIOLET's bids overlap each other and overlap RED, so neither can win.
- Manchester, IA is unsold even though VIOLET expressed demand for it.

- In a Clock Auction VIOLET would see the under-demand on Manchester IA round by round and over-demand elsewhere. VIOLET could thus decide to stop bidding on other areas and end the auction winning Manchester IA.
- With price discovery rounds, FCC auctions have typically concluded with few unsold licenses.

Table of Contents

Section 5: FUEL Bidding Language Increases Risk with No Benefit

Bid Groups in the FUEL Auction

- A Bid Group or collection is proposed to be in the following form:

	Number of Licenses				
PEA	**0**	**1**	**2**	**3**	**4**
A*			Base	$10	$15
B			Base	$20	
C*	$–15		Base	$5	
Base price:	**$200**	**EARLY/MIXED BID GROUP**			

- The input to the auction has to distinguish Early from Late spectrum (Early indicated by * in above example), Main vs. Coordination round (coordination is "base" only). **So the licenses/blocks are not actually generic.**
- The collection then indicates differences in what you would be willing to pay to add or subtract licenses from your base package in each PEA.
- There are two broad issues for bidders with the approach of creating "collections":
  - The vast number of possible combinations is not meaningful; a bidder could conceivably specify all 10^{406} combinations of possible licenses. But it is other elements of the process that simplify it (restricting number of bids that can be made, solving by EA, etc.).
  - The "language" lets you bid all possible combinations but cannot fully specify valuations, which leads to bidding errors.
  - These two issues are discussed on the following pages.

10^{406} Packages

- Auctionomics at page 7: *There are 10^{406} packages that a bidder could possibly bid on, which is vastly more than any bidder can realistically evaluate and consider individually.*
- But for bidders, this is no different than any other auction – in Auction 97 AWS-3 there were 2^{1614} possible packages, in Auction 101 for 28 GHz, there were 2^{3072} possible packages. Both of these are greater than 10^{406}.
- In any case, 10^{406} is a number much larger than the estimate of the number of atoms in the universe – 10^{80} – it is impossible that a bidder would have such a large number of targets.
- In any realistic setting, bidders do not have infinite numbers of packages of interest to bid on:
  - Auction 97 lasted 341 rounds so no bidder could have expressed interest in more than 341 packages; 1,611 licenses sold; 3 unsold licenses representing <<1% of proceeds.
  - Auction 101 lasted 176 rounds, so a maximum of 176 different packages per bidder; 2,965 licenses sold; 107 unsold representing <<1% of proceeds.
  - Auction 102 lasted 91 rounds – 2,904 licenses sold; only 5 unsold (American Samoa).
- It is preferable for bidders to express all their target combinations via price discovery rather than attempt to express them in a bidding language with implied bids.

FUEL Bid Group Example

	Number of Licenses				
PEA	**0**	**1**	**2**	**3**	**4**
A*			Base	$10	$15
B			Base	$20	
C*	$–15		Base	$5	
Base price:	**$200**	**EARLY/MIXED BID GROUP**			

- Auctionomics Bid Group Example at page 9 – specifies collections of licenses representing 18 packages, **that are implied by the bid group.** These are the 18:

	Package	Bid Packages #1-#6: Number of licenses and Package Value					
		1	2	3	4	5	6
Market	PEA A	Base (2)	+$10 (3)	+$15 (4)	Base (2)	+$10 (3)	+$15 (4)
	PEA B	Base (2)	Base (2)	Base (2)	+$20 (3)	+$20 (3)	+$20 (3)
	PEA C	Base (2)	Base (2)	Base (2)	Base (2)	Base (2)	Base (2)
Package value		$ 200	$ 210	$ 215	$ 220	$ 230	$ 235
	Package	Bid Packages #7-#12: Number of licenses and Package Value					
		7	8	9	10	11	12
Market	PEA A	Base (2)	+$10 (3)	+$15 (4)	Base (2)	+$10 (3)	+$15 (4)
	PEA B	Base (2)	Base (2)	Base (2)	+$20 (3)	+$20 (3)	+$20 (3)
	PEA C	+$5 (3)	+$5 (3)	+$5 (3)	+$5 (3)	+$5 (3)	+$5 (3)
Package value		$ 205	$ 215	$ 220	$ 225	$ 235	$ 240
	Package	Bid Packages #13-#18: Number of licenses and Package Value					
		13	14	15	16	17	18
Market	PEA A	Base (2)	+$10 (3)	+$15 (4)	Base (2)	+$10 (3)	+$15 (4)
	PEA B	Base (2)	Base (2)	Base (2)	+$20 (3)	+$20 (3)	+$20 (3)
	PEA C	-$15 (0)	-$15 (0)	-$15 (0)	-$15 (0)	-$15 (0)	-$15 (0)
Package value		$ 185	$ 195	$ 200	$ 205	$ 215	$ 220

FUEL Bid Groups – Cannot Fully Specify Values

	Number of Licenses				
PEA	**0**	**1**	**2**	**3**	**4**
A*			Base	$10	$15
B			Base	$20	
C*	$–15		Base	$5	
Base price:	**$200**	**EARLY/MIXED BID GROUP**			

- FUEL Bid Group Example at page 9 – Examples of the 18 packages:
  - The "base bid" is $200 for two blocks in each PEA.
  - Another bid is $210 for three blocks in PEA A and two in each of PEA B and C,
  - Another bid is $220 for two blocks in PEA A and C and three in PEA B, etc.
- This bidding "language" does not allow a bidder to fully express its valuation function. This can lead to a bidder making many errors in bidding. For example:
  - One of the packages is a bid of $215 for 4 blocks in PEA A and two in each of PEA B and C. But the bidder may have preferred to indicate it would take two additional blocks in PEA A for $15 if and only if it can have two less in PEA C (i.e. 0 blocks for $15 less), at the same bid value of $200. There is no way to make that distinction in the bid group.
  - The collection implies a max bid of $240 – 4 blocks in PEA A and three in each of PEA B and C. This may be an undesirable package and may be over budget. The bid is placed automatically. The bidder cannot exclude undesirable combinations from the collection.
- Placing bids explicitly is less error prone and clearer for bidders.
  - Was part of the rules of Canadian 2500 MHz auction in 2015; was not extensively used.

Conclusions on Bid Group "Language"

- The Bid Group language does **not** allow a bidder to fully specify valuation function:
  - The combinations all use additive values (all values independent), which may not represent reality. Cannot specify different values for winning "either" compared to "both".
  - Impossible to specify explicit packages that are undesirable. Cannot explicitly check each bid out of 10^{406} specified.
- Bids are "implied" – may win a bid not actually intend to specify or that is not consistent with overall valuations. **Dangers in implied bids** and prone to errors:
  - A bidder may win all increments, which could be over budget, when the intent was to indicate an increase in one area offset by a decrease in another.
  - Could win all decrements, which would mean less than the "base" package, even though the base package is presumably the main target.
  - Valuation increments are always linear, additive values – so an increment of $10 for an additional license in PEA A is always included at $10 for any combination of licenses implied by the bid group.
  - Preferable for bids to be written out – no risk of winning what you don't want.
  - Similar Exclusive-OR bidding approach used in a Canadian auction in 2015 had the same issues. The feature was not well understood by bidders, was not used extensively and did not change the outcome. Has not been used in any subsequent auction (in Canada or elsewhere).

Table of Contents

Section 6: FUEL Format Would be Subject to Gaming

Example – Auctionomics FUEL Appendix

- How regional bidders can be impacted by the format…
- Auctionomics FUEL White Paper Appendix Example of "Competition Among Large and Small Packages" at page 19: *There are three areas with licenses for sale, labeled A, B and C, and four 20 MHz licenses available in each area. Areas A and B are large top-50 urban areas, with reserve prices of $100 per license, while area C is a small rural area, with a reserve price of $10 per license.*
- There are just two bidders in the FUEL example.
  - **National bidder X** would like to acquire 80 MHz of spectrum in all three areas, but cares most about winning licenses in areas A and B. If bidder X can win 80 MHz in the urban areas, it is willing to pay up to twice the reserve price for every license it acquires.
  - **Regional bidder Y** would like to acquire only one license in area C. Its overall budget is much smaller than that of bidder X, but it is willing to pay five times the reserve ($50) for its desired spectrum.
  - In this situation, it is efficient for regional bidder Y to acquire one license in area C and bidder X to acquire the remaining licenses.
- This result – **based on each bidder bidding its "Optimal Bid Group"** – is shown on the following page – identified here as Scenario 1.

FUEL Bidding Example – Scenario 1

- Based on the Auctionomics FUEL White Paper Appendix page 20:

Scenario 1: Large National Bidder X and Small Regional Bidder Y Both Win

Bidder X: Package Bids expressed by Optimal Bid Group

Bidder X Package Bid #1		Quantity of licenses			
		1	2	3	4
PEA	A	■	■	■	■
	B	■	■	■	■
	C	■	■	■	■
Bidder X price		$ 1,680			
Auction max bids		$ 1,680			

Bidder X Package Bid #2		Quantity of licenses			
		1	2	3	4
PEA	A	■	■	■	■
	B	■	■	■	■
	C	■	■	■	
Bidder X price		$ 1,660			
Bidder Y Bid	C	■			
Bidder Y price		$ 50			
Auction max bids		$ 1,710			

Scenario 1 WINNERS: Bidder X wins Package #2 and Bidder Y wins the Last License

- In this case, Large Bidder X bids its "optimal" bid group (truthful values), and both the large and small bidders win their target licenses. **Both bidders win**.
  - Works because Bidder X unchecked the "last" license in its Bid #2 – no guarantee in real auction that Bidder X will do that. Did not need to try to assess Bidder Y values.
- The auction maximum revenues are $1,710 representing the sum of Bidder X and Bidder Y, which is greater than $1,680 if Bidder X's 12 license bid were to be accepted.

FUEL Bidding Example – Scenario 2

- However, Auctionomics goes on to state (page 20): "In order to have won the last C license, bidder X would have to have bid a decrement higher than $50… In that case, bidder X would win all twelve licenses."
- The following Scenario 2 depicts this, using a decrement of $51:

Scenario 2: Large National Bidder X bids to eliminate Small Regional Bidder Y

Bidder X Package Bid #1		Quantity of licenses 1	2	3	4
PEA	A	■	■	■	■
	B	■	■	■	■
	C	■	■	■	■
Bidder X price		$ 1,680			
Auction max bids		$ 1,680			

Scenario 2 WINNER: Bidder X wins Package #1, Bidder Y wins nothing

Bidder X Package Bid #2		Quantity of licenses 1	2	3	4
PEA	A	■	■	■	■
	B	■	■	■	■
	C	■	■	■	
Bidder X price		$ 1,629			
Bidder Y Bid	C	■			
Bidder Y price		$ 50			
Auction max bids		$ 1,679			

FUEL Bidding Example – Scenario 2

- However, Auctionomics goes on to state (page 20): "In order to have won the last C license, bidder X would have to have bid a decrement higher than $50… In that case, bidder X would win all twelve licenses."
- The following Scenario 2 depicts this, using a decrement of $51:

Scenario 2: Large National Bidder X bids to eliminate Small Regional Bidder Y

Bidder X Package Bid #1		Quantity of licenses 1	2	3	4
PEA	A	■	■	■	■
	B	■	■	■	■
	C	■	■	■	■
Bidder X price		$ 1,680			
Auction max bids		$ 1,680			

Scenario 2 WINNER: Bidder X wins Package #1, Bidder Y wins nothing

Bidder X Package Bid #2		Quantity of licenses 1	2	3	4
PEA	A	■	■	■	■
	B	■	■	■	■
	C	■	■	■	
Bidder X price		$ 1,629			
Bidder Y Bid	C	■			
Bidder Y price		$ 50			
Auction max bids		$ 1,679			

- **The auction outcome is now entirely different: Bidder Y has been pushed out and auction maximum revenue is lower.** To do this, Large Bidder X has deviated from truthful bidding and shaded its value for Bid #2 – in the optimal bid group, in Scenario 1 it was worth $1,660 but in Scenario 2 it is worth $1,629.
- Since Bidder X is no longer truthful, it is engaged in strategic bidding – the only objective of this can be to eliminate Bidder Y.

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	C	■	■	■	■
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PEA	A	■	■	■	■
	B	■	■	■	■
	C	■	■	■	
Bidder X price		$ 1,629			
Bidder Y Bid	C	■			
Bidder Y price		$ 50			
Auction max bids		$ 1,679			

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- Since Bidder X is no longer truthful, it is engaged in strategic bidding – the only objective of this can be to eliminate Bidder Y.
- ***NOTE: Outcome would have been same without Bidder X bidding Package #2 at all.***

FUEL Gaming Incentives

- Large bidders can bid in a way to game the bid collections and directly impact smaller, regional bidders:
  - The Auctionomics example (FUEL White Paper Appendix) shows how bid shading – non-truthful bidding – can eliminate a regional bidder,
  - Large bidders can also simply bid without leaving room for regional bidders. What is the incentive to "play nice"?
- With the FUEL bidding language, one bid could be placed for all 9 blocks at a very high price to win over all other bids, creating an auction outcome with only one bidder.
  - Bidders in a Clock or SMRA auction may also bid for all items, but with multiple rounds are likely to end up with a subset.
  - With FUEL a large 9 block bid can be treated as all-or-nothing, so losing is costless and winning would have high foreclosure value. Bidders could also use this mechanism to create large losing bids with the sole purpose of influencing prices of other bidders.
- There are other examples of gaming incentives that are built into FUEL:
  - Coordination round – little incentive to participate other than to mislead. Auctionomics at page 7 states: "Some bidders, especially smaller ones, may wish to use the Coordination round to advertise their preferred packages…". Unclear why a bidder in any auction would want to "advertise" what it wants. In any case, the operating areas of small and regional bidders in the US are already well-known.
  - Definition of large "national" bids versus small bids – these are based on the size of the bid not on the size of the bidder. Any bidder could create large non-winning bids which would serve only to influence prices of other bidders. Bidders may place both large all-or-nothing bids as well as EA-constrained small bids.
  - The second price mechanism incents bidders to focus on values of the other bidders to place bids to influence prices.

Table of Contents

Section 7: Competitive Measures Required for Combinatorial Auctions

Strong Competitive Measures Required

- Regional carriers would not likely place large national bids because the $ amount would be too high. With EA-based bids – packages of PEA's by EA – these bidders face an insurmountable threshold problem:
  - Have to bid the value of entire EA's in order to win over other bidders bidding on entire EA's or nationally, or count on other small bidders bidding collectively to win.
- The combinatorial aspect of the auction favors large national bidders that can more easily bid to "fit" together:
  - Many possibilities for large bidders: bid for 3, 4, 5 blocks nationwide all-or-nothing – no regional bidders can fit in,
  - Regional bidders only fit in if large bidders leave "holes" in their bids to allow for that. Bidders can signal this in the Coordination round, but this would more likely have the opposite effect – large bidders would know exactly which holes to "plug".
- To even partially mitigate the substantial impediments to small bidders in a combinatorial auction would require strong measures including caps and reserves specifically designed to overcome these issues. For example:
  - Spectrum Cap – limiting any bidder to a certain quantity of MHz.
  - Set Aside or "Reserved" Blocks – providing for a fixed number of blocks available to small/regional bidders.
  - Or a combination of the above.
- Competitive measures are needed to ensure that the total spectrum MHz "pie" cannot be monopolized by one or two large bidders.

Table of Contents

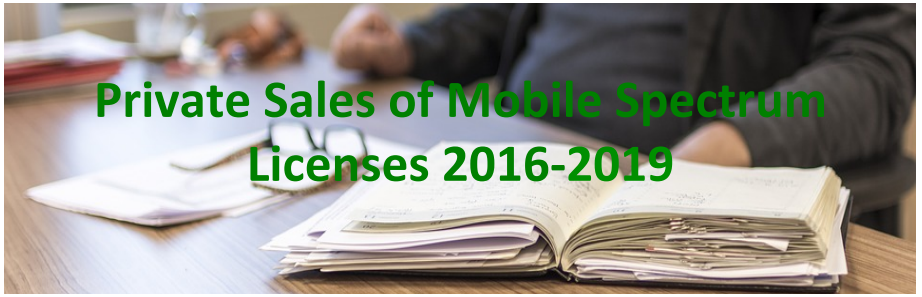
Appendix: LYA Background

Introduction to LYA

- LYA is an independent expert consulting firm founded in 1993 to provide management consulting services to support the telecommunications industry.
- Consulting engagements cover:
  - Spectrum auction bidder support and planning, including in bid room;
  - Market design for a 2-Sided Auction Format Proposal;
  - 5G Spectrum strategy and assessment of spectrum needs;
  - Private auctions of spectrum licenses and other assets;
  - Regulatory and policy support, expert testimony and reports;
  - Investment and financial analysis, due diligence, business plans;
  - Market research – quantitative including published research reports.
- LYA brings its own in-house Auction Platforms supporting all auction formats used in the US, Canada and Europe for spectrum auctions, as well as for sequential auctions (Assignment Phase) in addition to having developed an innovative format for a 2-Sided Auction, to effectively conduct a negotiation between sellers and buyers.
- LYA has been active in wireless/mobile, spectrum issues and in spectrum auctions since 1995 and has provided support to bidders since 1999.

Experience, Expertise and Innovation in Broadband, Spectrum and Auctions

Recent Spectrum and Auction Mandates

700 MHz Combinatorial Clock Auction 2014	2500 MHz Combinatorial Clock Auction *with OR Bids* 2015	3.6 GHz Combinatorial Clock Auction 2016 - 2017	5G Spectrum Strategy 2017-2018
AWS-3 SMRA Auction 2014 - 2015	600 MHz Clock Auction 2016 - 2017	2-SABA – Two-Sided Auction Format 2016 - 2017	Combinatorial Sealed Bid Auction 2018
28 GHz SMRA Auction 2018	600 MHz Combinatorial Clock Auction 2019	 Private Sales of Mobile Spectrum Licenses 2016-2019	

LYA Core Team

Johanne Lemay

MBA from Concordia University and Engineering Physics degree from Laval University. Expertise in auctions has been retained by key industry stakeholders since 1999, notably with respect to strategy, valuations, advice in public consultation processes and bidder training and strategy development.

Robert K. Yates

MBA from Concordia University, Masters Degree in Industrial Engineering – Management Science/Operations Research and Bachelors Degree in Electrical Engineering, from the University of Toronto. Has supported bidders for entire auction process, from the initial public consultation to auction training and preparation, valuation, bid room operational and tactical support and post auction review.

Adrian Vetta, McGill University

Trottier Fellow in Science and Public Policy at McGill University. Ph.D. in Math (MIT), M.Sc. (Math) and B.Sc. (Economics), London School of Economics. Professor in the Department of Mathematics and Statistics and the School of Computer Science. Has been a key member of the LYA team since 2012. Professor Vetta has been active in investigating the theoretical underpinnings and key elements of auction processes.

Sam Birnbaum, BA

Expert programmer and analyst for spectrum auctions, having worked with LYA since 2012. Background in algorithmic design, robotic bidders and second price auctions in Canada, the USA and Ireland. Assessment of auction dynamics and support in auction bidding and round tracking tools for CCA auctions.

LYA also has other resources available to support specific mandates

Examples of Publications – Prof. A. Vetta

- V. Narayan, E. Prebet and A. Vetta, "The declining price anomaly is not universal in multi-buyer sequential auctions (but almost is)", to appear in Proceedings of 12th International Symposium on Algorithmic Game Theory (SAGT), 2019.
- V. Narayan, G. Rayaprolu and A. Vetta, "Risk-free bidding in complement-free combinatorial auctions", to appear in Proceedings of 12th International Symposium on Algorithmic Game Theory (SAGT), 2019.
- G. Berbeglia, G. Rayaprolu and A. Vetta, "Pricing policies for selling indivisible storable goods to strategic consumers", Annals of Operations Research, 274(1-2), pp131-154, 2019.
- G. Berbeglia and P. Sloan and A. Vetta, "The finite horizon, undiscounted, durable goods monopoly problem with finitely many consumers", Journal of Mathematical Economics, 82, pp171-183, 2019
- G. Berbeglia, S. Boodaghians and A. Vetta, "Tight bounds on the relative performances of pricing mechanisms in storable good markets", Proceedings of 11th International Symposium on Algorithmic Game Theory (SAGT), pp267-271, 2018.
- M. Dupre la Tour and A. Vetta, "The combinatorial clock auction: the effects of strategic behavior and the price increment rule on social welfare", Proceedings of 19th ACM Conference on Economics and Computation (EC), pp91-108, 2018.
- N. Bousquet, Y. Cai and A. Vetta, "Welfare and rationality guarantees for the simultaneous multiple-round ascending auction", Proceedings of 11th Conference on Web and Internet Economics (WINE), pp216-229, 2015.
- S. Boodaghians and A. Vetta, ``The combinatorial world (of auctions) according to GARP", Proceedings of 8th International Symposium on Algorithmic Game Theory (SAGT), pp125-136, 2015.